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Managing risks related to functional changes by Design Alliance

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Abstract

The aim of this paper is to introduce a new model to manage risks related to functional changes. The model integrates users in the building design process through an open building based design approach Design Alliance (DA). The main conclusion is that building owner can manage the risks related to changing functions by DA. In the new 40 million euro healthcare centre case project the functional changes had no negative effect to the project budget, schedule, quality or cooperation between stakeholders. The users and the building owner stated that the co-working in design process exceeded their expectations.

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Keywords: alliance; briefing; design management; flexibility; integrated project teams; open building; programming, risk management

1. Introduction

Current construction management practices are based on the assumption that functions that a user performs in the facilities are fixed [1]. Therefore, traditional construction management process aims to create facilities for specific users, that are well-known. It is assumed that users are able to define all their requirements during the project briefing stage and approve the design solutions presented to them on print in the design phase.

Paradoxically, in reality the user functions change continuously. For example in the healthcare sector, a new organization structure may change the main function from a single patient treatment to dynamic group care. As a result, the need for facilities change from individual doctor's offices to group work room(s) or back office model.

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The traditional construction management practices generate several risks for building owners related to functional changes. In some cases the risk materializes, which may significantly delay the briefing and design processes and increase the project budget. For example in the Insel Hospital INO project finalization of the brief took several years due to several changes in user functions i.e., new medical procedures were introduced, a new head of surgery was hired with new staffing, new facility and equipment requirements, a change in the market for services occurred, new regulations were introduced, and the pediatric facility was scheduled to be expanded [2]. Similar problems were experienced in Sutter Health's Cathedral Hill Hospital project in San Francisco [3].

The aim of this this paper is to introduce a new model to manage risks related to functional changes from building owner perspective. The research method is action research. Based on the literature review findings, the authors develop a new procurement method for design: Design Alliance (DA). Following that, the DA is piloted and further developed in a case project. The case project is a new 40 million euro healthcare centre located in the city of Järvenpää, Finland. Finally, the results of the case project are collected and analysed. This study focuses on the briefing and design phases of the construction project.

While several methods have been presented to manage functional changes [e.g. 1,2,3], these methods are not widely used in the industry. This case study aims to increase understanding on how to integrate users with changing functions in the building design process through an open building and user-friendly design approach DA.

The paper structure is as follows. Next, earlier research is reviewed. After that, the research approach is presented and the DA is conceptualized. Finally, the results with discussion and conclusion are presented.

2. Aspects of the design management

We first review the literature related to the challenges of the traditional briefing and design management practises especially in healthcare projects. Secondly, we briefly address the literature that presents potential solutions for example open building approach, target cost method and collaborative project delivery to develop the theoretical background for the DA approach.

2.1. Briefing and design management in traditional healthcare projects

In the architecture/Engineering/Construction (AEC) industry briefing is the stage of construction process in which owners define the requirements for their construction project to lead the design process [4]. According to a wide benchmark study by Popov [5], the briefing process in the healthcare sector has typically four phases: planning and commencement, functional programming, space programming, and approval of the final document. At the planning and commencement of the briefing, the briefer reviews background material and makes an execution plan to generate the brief. Functional programming covers envisioning the future of the organization, structures and operations that will be accommodated by the new facility. Space programming is about defining the scope and the quality of the facilities. The approval of the final document is the back end of the programming process.

Clients, designers and academics present critics on current briefing practices and the brief content in the healthcare sector. Strategic thinking and user goals are often lacking from the project briefing. Moreover, the designers complain that the briefing documents are not useful in practice. In effect, the briefs are often too lengthy and containing too detailed specifications, that are not clear, consistent or complete. [4,6,7]. Clients sometimes have the impression that the brief is poorly understood by architects, or even ignored [6]. In briefs the facilities are usually programmed for specific purposes using a fixed detailed room program. Such practices do not support user's change management in construction process [1]. Finally, it is infrequent that briefs contain measurable targets [7].

After the briefing phase, the design of the building begins. The design phase seeks to find design solution to fulfil the requirements set in the brief. The design process can be divided into functional design, conceptual design, scheme design, design for permit, design for procurements, design for execution, and finalizing the designs as-built. The main challenges [8] in the design process include poor flow of design process and the lack of interest to

generate value for the facility users. Consequently, unnecessary rework is done. The main reason for this is poor ordering of the design tasks. It is not only a question of better briefing to improve the value of facilities, but also to improve the practices and tools of design management, and to put emphasis on the use-value of the building.

2.2. Open building

The DA utilizes open building method. Open building is a method of producing user-oriented facilities, ordering efficient design tasks and managing changing user functions. The basic idea in open building is to establish principles for dividing and combining building subsystems in a way that minimizes their interdependencies by transforming subsystems without redesigning or renewing the entire building. A building can be divided into a permanent base building (or "support") and modifiable spaces (or "infill") [9]. Kendall [2] has suggested that in healthcare the infill should be divided into secondary system (e.g. walls) and tertiary system (e.g. furniture) to manage complexity. Moreover, open building approach seeks to ensure that design decisions enable buildings to change and thus remain valuable in the future. [2]

In particular, open building differs from the conventional way of construction management in terms of management of user requirements and ordering design tasks. In open building brief, the functional requirements are not described on a single space program that determines every room that should be implemented into the design. A single room program does not satisfy a wide range of needs and preferences as well as the future demands of the users. The open building approach also acknowledges that building design is a collaborative process, which involves many participants with diverse backgrounds. Thus, the management in ordering design tasks is of utmost importance to reduce complexities and to balance divergent interests of the related parties. Involving the users in the decision-making process is a priority in open building. [10]

According the open building principles, a building is generally required to offer two quite different forms of flexibility: modifiability and service flexibility. Modifiability refers to the capacity of the building to be adapted to changes occurring in the future, such as changes of users. Service flexibility, also known as adaptability, refers to the capacity of the facilities to be operated and used in different ways. [1]

Saari et al. [1] have developed a practical process to utilize open building principles in the project briefing stage. In the briefing stage, the buildings should be divided into two parts: a permanent base building and an infill. The requirements for infill contain flexible room program including the information of what types, how much, and what kind of interior environment of spaces the infill must offer to be implemented in the design and use phases. In effect, the main requirements for the base building include information on how the base building will enable the infill requirements and support the infill to adapt with user function changes.

2.3. Target cost method and collaborative project delivery

Target cost method can be utilized to manage costs in DA process. The main principle of target costing is to make cost and value drive the design process instead of calculating the cost after the design is complete. A target cost for the project is an outcome of the feasibility studies and is the target the design team is going to design to. Systemic application of target costing leads to significant improvement of project performance. According Zimina et al. [3], the final costs of projects utilizing target cost method are on average 15% less than market cost. Target costing has been utilized in Finland since the 1970's to generate project budget. It is widely in practical use.

Kiiras et al. [11], have successfully implemented target cost method into an open building design management. The adoption of this model enables (1) to set a target price based on a flexible building program (brief), (2) to examine an overall design by comparing a building element estimate (BEE) against the target price, (3) to break down the BEE into a target budget (cost plan) according to design packages e.g. base building and infill, (4) to examine the design solutions of each design package against the target budget by using a detailed bill of quantities

and a detailed cost estimate, (5) to break down these cost estimates into procurement packages, and (6) to utilize the expertise of suppliers and subcontractors to develop the design solutions and meet the target budget.

Collaborative construction project arrangements are often needed to foster design flow. Recently project partnering, project alliancing and integrated project delivery have been presented to the market. These project delivery arrangements have several similar features such as early involvement of key parties, transparent financials, shared risk and reward, joint decision-making, and a collaborative multi-party agreement [12]. Integrating target-costing approach with collaborative project arrangements generates natural motivation for all project stakeholders to help each other to improve the design flow and value-in-use of the facilities [13].

2.4. Findings of the literature review

According to the reviewed studies, the building brief should be based on user's strategic vision and project's measurable goals for base building and infill. The brief should be concise and contain clear, consistent and complete information. In addition to the brief, more emphasis is needed on the ordering and managing design tasks to improve the flow of the design and user orientation. The open building approach, target cost method and collaborative project arrangements are potentially highly beneficial to address these questions. Based on the literature review results, the authors develop a new procurement method for design: design alliance (DA).

3. Research design

3.1. Research process

The research is conducted as an action research. The research process utilizes Lewin's [14] process of change and consist of unfreezing, change and refreeze phases. In the unfreezing phase, spring of 2013, the authors were recruited as project managers and advisors to a new healthcare centre project located in the city of Järvenpää, Finland. Based on the literature review findings and project planning activities, the authors investigated the DA as a potential solution to tackle the issues. In the change phase, the authors further developed the DA through expert group work and piloting it in the case project. The professional group was constructed from the academic and practical construction and healthcare experts in the areas of construction management, healthcare design, BIM management, and procurement law. In the summer of 2013 the DA was procured to execute the design work. Finally, in the refreezing phase the authors collected and analysed the results of the DA to manage risks related to functional changes in the conceptual design phase.

The research data collection process, description, and utilization of the data are described in the Table 1.

Table 1. The research data

Data collection	Description of the data	Utilization of the data
1. Investment decision (1/2011)	The project brief and procurement materials for design and build competition in 2011 produced by the former project managers (621 pages)	Providing background information for DA brief
2. Investment decision (6/2013)	The results of feasibility studies, the risk analysis of the project, two drafts and final version of the DA brief, two drafts and final version of DA procurement materials, and DA audition materials produced by the project managers (548 pages)	Formulation of the DA
Designers' selection decision (9/2013)	Two drafts and final version of DA agreement and DA audition materials produced by the project managers and designers (252 pages)	Finalizing the DA
Design milestone 1 analyses (1/2014)	The designs related to functional solution and the analysis of the solution produced by the project managers, designers and users (135 pages)	Observing the effectiveness of the DA
Design milestone 2 analyses (3/2014	The design related to base building and type rooms and the analysis of the solution produced by the project managers, designers and users (155 pages)	Observing the effectiveness of the DA

3.2. Description

The case project, a new healthcare centre, will offer the basic health and social services for 35 000 inhabitants of the city of Järvenpää, Finland. The project consist of following objectives:

1. The design process and solution of the building must enable the city of the Järvenpää to generate health benefits for the inhabitants via new healthcare processes and methods
2. The design solution must support the healthcare functions and be adaptable to function changes
3. The design solution must be conformable to the budget and enrich the townscape
4. The facilities and healthcare operations must be operative in October 2016

This healthcare project offers an interesting case study platform to develop, test and evaluate how DA is able to manage the functional change. In effect, the functional change of the user i.e. the social and healthcare services of the city has been intense for years. To illustrate this change the room programs for the new healthcare centre were compared from January 2011 and from January 2014. The room programs were programmed to determine the rooms that the facility must have to support the functions that time.

Project's architects generated the first room program in January 2011. The main users' units were surgery, emergency duty, rehabilitation, social work, radiography, laboratory tests, and the ward for patients with acute illnesses. The functions in the units were mainly related to single patient treatment, which needed surgery rooms for each staff member. The user functions required the floor area of 8000 sqm2.

Architects generated the second room program in January 2014. The main users' units were the same as in the room program generated in January 2011. The functions needed the same amount of total floor area (8000 sqm2). However, the room program was changed radically. In effect, the functions in several units were changed from single patient treatment to dynamic group work. The interaction requirements between the units were changed as the patient flow between the units was changed.

As a result of the users functional changes during three years 27 % of the room program was updated. In other words, significant proportion of the facilities did not support the functions after a relatively short period of time.

4. Design alliance

Based on the literature review results, the authors developed the first version of a new procurement method for design, design alliance (DA). The DA is a design procurement, agreement and open building based design management method that aims to integrate designers, owner and users to collaborate, improve design flow, and find design solution that fulfils the requirements set in the brief. Following that, the DA was further developed by professional group work that utilized a risk management approach. The risk management approach consist of three phases: 1) identification of the risks related to design flow and value-in-use for the user, 2) planning of management actions, and 3) integration of management actions into the DA model. The risks related to design flow and decrease of value-in-use were identified. Here the flow refers to the perspective of the customer of the design work (building owner) and how the customer perceives the progress of design work. Moreover, the value-in-use refers to the fit between the facilities and user's functions. The identified risks and management actions related to design flow are presented in the Table 2. The identified risks and risk prevention actions related to value-in-use are collected in the Table 3.

Table 2. The identified risks and prevention actions related to design flow

Risk	Risk prevention actions for DA
The changes in user functions delays the design progress	Integrate the users to the design process with flexible room program, set milestones for the design process, separate procurements of the infill and base building, and set target cost for infill and base building
The design solution does not fulfil the requirements of the brief	Divide the design work of design alliance into milestones i.e., functional solution (M1), conceptual solution (M2) construction permit designs (M3), and contracting offers (M4) and verify that the design solution alternations fulfil the requirements in each milestone with audits and financial incentives.
The users do not have enough motivation to participate in the design process	Users participate in the design alliance procurement process. Utilize 3D and 1:1 ratio to illustrate the design solutions and their operative impact to the users. Integrate the users only to the design tasks that they consider interesting with open building approach.

Table 3. The identified risks and prevention actions related to value-in-use

Risk	Risk prevention actions for DA
The user functions change after the design phase	Set measurable requirements for flexibility of the building in the project brief (e.g. service flexibility and modifiability) and test the flexibility of the design solution in virtual environment and in separate test sets.
The users cannot fully articulate the requirements they have to the designers	Utilize building information modelling (BIM) i.e., use virtual 3D modelling to illustrate the design solutions and simulation to illustrate the user processes in the facilities
	Build test facilities i.e., build concept rooms where users can test real functions and improve the design solution and procure the infill construction work so that the users are able to test the fit between facilities and functions before the final acceptance of the construction work.

The DA is responsible of all design and design management work in the project. The parties of the DA agreement are designers, user and owner. The contractor is not involved in the early phases of DA as only the parties that have the greatest influence on serving the user in early phase of the project are involved.

The main features of the DA design management process are open building approach, virtual and physical occupancy and target cost method. The design work and decision making is divided into different design packages according the open building principles. Each design packages has it's own target cost to lead the design work. Virtual and physical occupancy enable the users and designers to test whether the design solution fulfils the functional requirements. DA utilizes virtual 3D 1:1 modelling by using CAVE technology and physical testing of infill's design solutions.

In DA, the design solution is analysed by internal and external auditors in four milestones i.e., functional solution (M1), conceptual solution (M2) construction permit designs (M3), and building contracting offers (M4). Financial incentives are an important part of the DA concept. In effect, approximately 40 % of the compensation of the designers are based on reaching targets in each milestone. Moreover, the designers and building owner share the positive and negative risks of the project. In the DA compensation model the designer gets 20 % sanction or 20 % bonus according to the evaluation in each milestone.

The following key factors are analysed in each milestone:

- Quality: Does the design solution fail to meet, meet or exceed the functional, quality and flexibility requirements set on the infill and base building in the brief?
- Costs: Is the design solution in line with the investment and maintenance budget set on the brief?
- Time: Have designers generated alternative solutions and are all designs produced on time?
- Collaboration: Are users and owners satisfied with the collaboration with designers?

In DA it is important to carefully design the user collaboration process as the collaboration evaluation is one of the key factors: if users are not satisfied to the participation in the designing the facilities, the designers will have sanctions. In the final milestone, the target building cost is compared to the actual building costs i.e., contracting price. If the building contracting prices exceed the budget, the designers receive sanctions instead of a bonus.

5. Results from managing changing user functions with DA

5.1. The DA brief

The DA brief sets measurable targets for flexibility, infill and base building. The brief was made to enable the management of functional change in design and use phases. The targets in the brief were formulated based on several information sources, particularly on feasibility studies, scenario work, and benchmark data. The main requirements for flexibility and infill are described in Table 4.

Table 4. Main targets for flexibility and infill for the DA in case project (flexible room program)

Room type	Space need (sqm2)	Main daily functions	Requirements for service flexibility	Requirements for modifiability	Requirements for interior environment
Surgery and administration	3000 - 4000	1000 customers	Type rooms must enable functions of all surgery units	30 type rooms must be modifiable to ward rooms	Room temperature management must be of a high standard, 20-22 C in winter and 23-26 C in summer. CO2 emissions must be under 700 ppm
Operation rooms	120 - 160	50 operations	Type rooms must enable functions of surgery and emergency		
Ward	1200 - 1560	60 beds	Type rooms must enable functions of all surgery units		
Dentist and diagnostic	1100	220 customers, 300 diagnostic missions			
Support functions	1930	1000 dishes, 300 staff			

Each row in the flexible room program has two targets i.e., the range of values in where the designers can manage the functional change during the design process and the type of spaces the infill must enable in use. The main requirements for the base building in the case project are:

- The gross floor area of the building cannot exceed 13 500 sqm2 and it must enable infill for 8000 sqm2 as described in the infill requirements.
- The building must reach the LEED Gold level standards
- The target cost for the building is 40 000 000 € (infill parts 14 000 000 €) and the maintenance costs of the building must not exceed 1 190 000 € per year

During the M1 and M2 the designers have felt that the DA brief have gave a good flexibility for them to search acceptable design solutions and manage the functional changes. Moreover, the users have felt that they have been able to effectively develop the functions concurrently with design process. However, the implementation of the DA brief needed much education and development work for the DA team. For example, the targets set in the brief generated numerous critical discussions in the agreement negotiations stage of the DA due to the strong link between the targets and financial compensation for the designers.

5.2. How the DA succeeded to manage functional changes?

The performance of the DA approach is evaluated through a milestone analysis of two milestones that are completed i.e., functional solution (M1) and conceptual solution (M2). The evaluation was made by an evaluation group that contained experts from the area of cost management, BIM and open building. The main information sources for the evaluation were BIM models, satisfaction survey for users and building owner and benchmark cost data. The results of the milestone analysis are presented in Table 5. Summary of milestone success is presented in following scale: comprehensive success (full or nearly full bonuses), Good, Normal (no bonuses / sanctions), Failure, and Comprehensive failure (full or nearly full sanctions).

Table 5. Results of the M1 and M2

Key factor	M1: functional solution	M2: conceptual solution
Quality	The design solution exceeded functional, quality and flexibility requirements.	The first version was not accepted due to conflicting design documents. However, after the audit and development period of three weeks, the design solution achieved functional, quality and flexibility requirements.
Costs	The design solution is within the investment and maintenance budget	The developed design solution is within the investment and maintenance budget
Time	Alternative solutions (9) have been generated and all designs have been made in time and were of good quality	Alternative solutions (3) have been generated and the developed designs were made in time and were of good quality
Collaboration	User and owner are very satisfied with the collaboration	User and owner are extremely satisfied with the collaboration
In summary	Comprehensive success performance relative to targets	Good performance relative to targets

According to the evaluation results, the DA has succeeded in the conceptual design phase. The DA approach is potentially highly beneficial for the building owner in projects where functions change. Moreover, the users and building owner stated that the co-working and user orientations in design process exceeded their expectations. The main reasons for the good satisfaction were the integration of user to design tasks of their interest, utilizing 1:1 and 3D visualization of design solutions and service oriented design process.

In the evaluation process the flexibility of the design solution, especially for the base building, to manage functional change in use phase was analysed. The evaluation was made by testing whether it is possible to modify the infill to support different functions during the use phase. According to the evaluation results, the design solutions fulfilled the targets that were set in the brief for the design flexibility.

6. Discussion and conclusion

The functions of the facility user changes over time – especially in the healthcare sector. Current construction management practises in general are based on the assumption that functions are mainly fixed. According to earlier literature, new briefing practices and design management tools are needed to improve the value of facilities and managing the change. For example, target cost method and collaborative project arrangements have been discussed in the academia and applied in practise to address these issues.

The aim of this this paper is to introduce a new model to manage risks related to functional changes from building owner perspective. The main result of the study is that building owner can manage the risks related to changing functions by Design Alliance DA method in the design phase of the building project. The benefits of the DA are promising. In the case project the intensive functional changes were successfully managed in conceptual design phase. The major functional changes did not negatively affect the project budget, schedule, quality or co-operation between parties. Moreover, the users stated that the co-working and user orientations in design process

exceeded their expectations. The main reasons for the excellent satisfaction levels were the integration of user to design tasks of their interest, utilizing 1:1 and 3D visualization of design solutions and service oriented design process. Furthermore, according to the auditions made in the milestones, the design process utilized successfully open building approach. The designers were motivated to take these actions and reach targets with financial incentives (bonuses and sanctions).

The ability of the DA to manage the functional change within the project targets is very valuable for building owners. For example in hospital projects in Finland, it is common that the functional change usually increases the scope of the project. While the room program is fixed in the brief phase, the functional change is managed by adding more rooms into the program and increasing the project cost budget.

The findings of this paper are in line with previous literature. The results related to open building approach, target cost approach and alliance and IPD models can produce significant benefits in time, cost, quality, cooperation and value-in-use management in construction projects. In the future it would be pivotal to study the progress of the case study and further analyse the implications of the DA. Moreover, it is important to evaluate how the targets of the flexible room program are enabled to manage the functional change in the use of the building.

References

[1] A. Saari, M. Kruus, A. Hämälainen, J. Kiiras, (2007). Flexibuild – a systematic flexibility management procedure for building projects. Facilities, 25 (3/4), 2007, pp. 104-114.
[2] S. Kendall, Managing Change: the application of Open Building in the INO Bern Hospital, In Design & Health World Congress, 2005
[3] D. Zimina, G. Ballard, C. Pasquire, Target value design: using collaboration and a lean approach to reduce construction cost. Construction Management and Economics, 30(5), 2012, pp. 383-398.
[4] N. Ryd, Facilitating construction briefing–From the client's perspective, Nordic journal of surveying and real estate research, 1(1), 2004, pp. 86-101
[5] L. Popov, Hospital Facilities Programming: An Opportunity for Vanguard Medical Practices. Australasian Medical Journal, 3 (9), 2010, pp. 591-597
[6] T. Bogers, J.J. van Meel, T.J. van der Voordt, Architects about briefing: recommendations to improve communication between clients and architects. Facilities, 26(3/4), 2008, pp. 109-116.
[7] M. Elf, I. Malmqvist, An audit of the content and quality in briefs for Swedish healthcare spaces, Journal of Facilities Management, 7(3), 2009, pp. 198-211.
[8] L. Koskela, P. Huovila, J. Leinonen, Design management in building construction: from theory to practice. Journal of Construction Research, 3(01), 2002, pp. 1-16.
[9] J. Habraken, De Dragers en de Mensen, Amsterdam: Scheltema en Holkema, 1962, First English-language edition in 1972, Supports: an Alternative to Mass Housing, The Architectural Press, London and Praeger, New York.
[10] Ş. T. Pektaş, B. Özgüç, Virtual prototyping for open building design. Open House International, 36(4). 2011, pp. 46-56
[11] J. Kiiras, M. Kruus, P. Huovinen, 2005, Cost Management under Construction Management (CM) Contract - in The Case of Large Building Projects in Finland. Third International Conference on Construction in the 21st Century (CITC-III), 2005
[12] P. Lahdenperä, Making sense of the multi-party contractual arrangements of project partnering, project alliancing and integrated project delivery. Construction Management and Economics, 30(1), 2012, pp. 57-79.
[13] W. Jung, G. Ballard, Y. Kim, S. Han, Understanding of Target Value Design for Integrated Project Delivery with the Context of Game Theory. Construction Research Congress 2012: pp. 556-563
[14] K. Lewin. Group decision and social change. Readings in social psychology, 3, 1947, pp. 197-211.